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tered from the direct rays of the sun. In some cases the whole of the piece of beef disappeared.

The small insects seem to live but a short time, although they are touched by only two to four hairs. The substance seems to be soon taken out of the insects. In my opinion, it is a true insectivorous plant. (Proceedings Amer. Assoc. Adv. Sc., 1875.)

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A CENTURY'S PROGRESS IN AMERICAN ZOÖLOGY.

BY A. S. PACKARD, JR.

THE title of this article is almost a misnomer, since American zoölogical science dates only from 1796, when Barton published his Memoir on the Fascination attributed to the Rattlesnake, while his Facts, Observations, and Conjectures on the Generation of the Opossum appeared in 1801. These were simply memoirs, but still talented productions and not unworthy to begin the century. Previous to this, John Bartram published a few zoölogical tracts in the Philosophical Transactions of the Royal Society of London, the first appearing in 1744, while his Description of East Florida, etc., was published in London in 1769.

John Bartram was born in this country, and so was Barton ; but the latter was, perhaps, the more genuine biologist, and his work was so well appreciated in England that he was called by Swainson the " father of natural history in America." The first century of American zoölogy should, then, date from 1796, and it had a worthy beginning.

American systematic zoölogy may be said to date from the years 1808–14, when the successive volumes of Wilson's Ornithology were published, though it should be remembered that Wilson was born and bred in Scotland. Thus, with the exception of Bartram's and Barton's works, what we have to say of American zoölogy (including animal physiology and psychology and embryology) covers only a little over half a century.

The next work was by Prince Bonaparte, on birds, a volume complementary to Wilson's great work, and published in this country in 1825–33.

But the first general work by a native-born American was Dr. Richard Harlan's Fauna Americana, published in 1825. This was succeeded by Dr. John D. Godman's work on North American Mammals, published in three volumes in 1826–28. Bartram,[1]

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[1] John Bartram was born at Darby, in the suburbs of Philadelphia.

Barton, and Harlan were born in Philadelphia and taught anatomy there. Godman was born in Annapolis, and lectured on anatomy in three medical colleges, but not in Philadelphia. On the whole, American zoölogy took its rise and was fostered chiefly in Philadelphia by the professors in the medical schools; and zoölogy the world over may be said to have sprung from the study of human anatomy, as taught at the anatomical centres of Italy, France, England, and Germany.

The last half-century of progress in zoölogy in America may be divided into three epochs: —

(1.) The epoch of Systematic Zoölogy, during which a few physiological essays appeared. To this department of zoölogy a most decided impulse was given by the Smithsonian Institution, which went into active operation in 1847, while the study of the fossil forms (palæontology) was greatly accelerated by the influence of national and especially state surveys.

(2.) The epoch of Morphological and Embryological Zoölogy. This period is due to the arrival of Louis Agassiz in this country, in 1846, resulting in his lectures on comparative embryology and the foundation of the Museum of Comparative Zoölogy, where American students, who were attracted by the fame of Agassiz, were instructed in the methods of Cuvier, Von Baer, Döllinger, and Agassiz himself, and zoölogy was studied from the side of histology and embryology, while palæontology was wedded to the study of living animals.

(3.) The epoch of Evolution, or the study of the genetic relationship of animals, based on their mutual relations and their physical environment. This period dates from the publication of Darwin's Origin of Species, in 1859.

Turning, now, to the first epoch, — that in which American systematic zoölogy took its rise, — we find that work was done which must necessarily precede more important studies on the embryology, geographical distribution, mutual relations, and psychology of animals, and which exerts a marked influence on the classification of animals, which nowadays is equivalent to tracing their genetic relationships; for the time is past when the animal world should be regarded as comprised within separate sub-kingdoms, between which there is no morphological or genetic connection.

The systematic works are so well known and our space so limited that we shall merely enumerate the names of our chief zoölogical authors. In the study of mammals the works of Audubon and his predecessors, already named, and of Thomas Jefferson, T. Say, J. Bachmann, G. Ord, S. F. Baird, T. Gill, Harrison Allen, J. A. Allen, E. D. Cope, Elliott Coues, J. Y. Scammon, B. G. Wilder, and W. S. Barnard, should be mentioned, with the palæontological essays of R. Harlan, J. C. Warren, J. Leidy, Cope, and O. C. Marsh, together with Godman's Rambles of a Naturalist and L. H. Morgan's work on the beaver, and physiological essays by J. Wyman, S. Weir Mitchell, J. C. Dalton, and others.

The ornithological works of Wilson, Bonaparte, Audubon, Nuttall, Baird, Cassin, and Coues, the more recent great work of Baird, Brewer, and Ridgway, Coues's Birds of the Northwest, and the many descriptive and biological papers of other authors, such as T. M. Brewer, Ord, J. P. Giraud, J. K. Townsend, A. L. Heerman, G. N. Lawrence, H. W. Gambel, J. Xanthus, H. W. Henshaw, H. Bryant, S. Cabot, T. M. Trippe, C. J. Maynard, and others, with the papers on distribution by Baird, A. E. Verrill, Allen, and R. Ridgway, together with those on fossil birds by Marsh and Cope, are all worthy of comparison with the best European works and papers.

The reptiles and amphibians have been described by Harlan J. E. Holbrook, T. Say, J. Green, Baird, C. Girard, E. Hallowell, L. R. Gibbes, C. A. Lesueur, J. E. LeConte, L. Agassiz, and Cope, and an entire assemblage of forms in the western Cretaceous and Tertiary formations has been discovered by Leidy, Marsh, and Cope. The anatomy of the nervous system of *Rana pipiens*, by Jeffries Wyman, is a classic, as are the researches of S. Weir Mitchell upon the Venom of the Rattlesnake and the Researches on the Anatomy and Physiology of Respiration in the Chelonia by S. Weir Mitchell and G. R. Morehouse.

The fishes of North America have been worked up by S. L. Mitchell, Lesueur, C. S. Rafinesque, D. H. Storer, J. E. Dekay, Holbrook, Agassiz, Girard, J. P. Kirtland, J. C. Brevoort, Wyman, Baird, Gill, Cope, W. O. Ayres, F. W. Putnam, T. G. Tellkampf, D. S. Jordan, H. C. Yarrow, C. C. Abbott, G. B. Goode, R. Bliss, S. W. Garman, and others; while the fossil forms have been described by J. H. and W. C. Redfield, Leidy, R. W. Gibbes, J. S. Newberry, Cope, and O. St. John.

In entomology the writings of Say, the two LeContes, F. E. Melsheimer, N. Hentz, T. W. Harris, S. S. Haldeman, R. von Osten Sacken, B. Clemens, J. D. Dana, G. Horn, S. H. Scudder, P. R. Uhler, H. Hagen, B. D. Walsh, A. S. Packard, Jr.,

A. R. Grote, W. H. Edwards, Henry Edwards, Sumichrast, H. C. Wood, A. Fitch, C. V. Riley, E. Norton, J. H. Emerton, C. Thomas, B. P. Mann, and others, are in most cases quite voluminous, though mostly descriptive, while the fossil forms have been described by Dana, Scudder, Meek and Worthen, S. I. Smith, and O. Harger. Their anatomy has been studied by Leidy, Scudder, and Packard.

The great work of Dana on the Crustacea of the United States Exploring Expedition placed him next to Milne-Edwards at the head of living authors in this department, and his essay on their geographical distribution is the starting-point for all such inquiries. In this connection should be noticed the essays of Dana on cephalization in animals, suggested in the first place by his studies on the Crustacea. The North American species have been described by Say, W. Stimpson, J. W. Randall, L. R. Gibbes, S. I. Smith, Hagen, Packard, and O. Harger, and the fossil forms by Green, Hall, Billings, Stimpson, and others.

The intestinal and higher worms have been worked up by D. Weinland, Girard, Leidy, Wyman, Stimpson, and Verrill; and of the aberrant classes, the Polyzoa have been carefully studied anatomically by A. Hyatt, the Brachiopoda by E. S. Morse and W. H. Dall, and several species of Tunicata described by C. A. Lesueur, Tellkampf, Louis and A. Agassiz, Verrill, and Packard; while their development has been studied by Morse.

The Molluscs of North America have been elaborated by Say, Gould, Lesueur, Rafinesque, Haldeman, I. Lea, T. A. Conrad, C. B. Adams, Stimpson, the two Binneys, J. W. Mighels, J. P. Couthouy, E. Ingersoll, A. Agassiz, T. Bland, T. Prime, Morse, J. Lewis, Dall, Tryon, Verrill, R. E. C. Stearns, Sanderson Smith, and others. The fossil Mollusca of entire formations have been described by Hall, Billings (of Canada), F. B. Meek, C. A. White, F. S. Holmes, O. St. John, C. F. Hartt, R. Rathbun, O. A. Derby, Whitfield, N. S. Shaler, Whiteaves (of Canada), and other palæontologists, and the quaternary species studied by Holmes, Dawson, Stimpson, Packard, Verrill, Matthews, and others. Their anatomy has been studied by Leidy, Wyman, Morse, Dall, and W. K. Brooks.

The Radiates (including the Cœlenterates and Echinoderms) have been carefully elaborated by Louis and A. Agassiz, and by Say, Stimpson, E. Desor, Ayres, Macrady, H. J. Clark, T. Lyman, and Verrill; while Dana's elaborate report on the Zoöphytes of the United States Exploring Expedition took the highest rank among systematic works. Numerous fossil forms have been brought to light by Hall, Billings, Meek, Shumard, White, Whitfield, W. H. Niles, O. A. Derby, and other palæontologists, and the distribution of the recent forms on both sides of the continent has been studied by Verrill and A. Agassiz.

The Sponges have been chiefly studied by Clark and Hyatt; and the Protozoa by J. W. Bailey, Clark, Leidy, and Tuttle.

We may congratulate ourselves on the high position of our palæontologists in the scientific world. The labors of James Hall, Meek, Billings, Dawson (of Montreal; we have included Canadian students in this article), and others have revealed whole platforms of life in the Palæozoic rocks; while the researches of Leidy, Marsh, and Cope in the Tertiary and Cretaceous beds of New Jersey and the West, and of Deane, Hitchcock, Leidy, Wyman, Newberry, Emmons, and Cope in Triassic and Carboniferous strata, have been productive of valuable results.

The discovery of the fossil bird-like reptiles of New Jersey, by Leidy and Cope; of birds with teeth and pterodactyls without teeth; of lemur-like monkeys, by Marsh; and the discovery by Leidy, Marsh, and Cope of connecting links between living ruminants and hog-like forms, and between elephants and tapirs; together with the genealogy of the horse, and the increase in the size of the brain of living forms over their Tertiary ancestors, as elaborated by Marsh, all present a mass of new facts bearing on the evolution of life on the American continent and the general doctrine of evolution.

In philosophical zoölogy Dana's papers on Cephalization, and Wyman's views on the Vertebrate Theory of the Skull, in his memoir on *Rana pipiens*, and his studies on antero-posterior symmetry in vertebrates; those of James Hall on the succession of molluscan life in palæozoic rocks; and those of Agassiz on prophetic and synthetic types, and laws of embryological growth as correlated with the succession of extinct forms, with other views in his Essay on Classification, should be here cited. The deep-sea researches of L. F. de Pourtales on the coast of Florida enabled him to state that "animal life exists at great depths in as great a diversity and as great an abundance as in shallow water." This was in 1867, before the cruise of the English steamer Porcupine and the researches of Carpenter, Thompson, and Jeffreys.

The epoch of embryology or the developmental study of animals was inaugurated by Agassiz in 1846. In the publication of his Contributions to the Natural History of the United States, mainly devoted to the developmental history of the radiates and turtles, Agassiz was assisted by H. J. Clark, who, under his training, became the best histologist our country has yet produced. W. J. Burnett, another histologist, was only inferior to Clark. Macrady, another of Agassiz's students, published some papers of importance on the Acalephs and their mode of development. Desor and Girard wrote on the embryology of worms. Memoirs of a high order of merit followed, from the pen and pencil of Mr. Alexander Agassiz. His embryology of the Echinoderms appeared between 1864 and 1874; the memoir on the Alternation of Generations of the worm, *Autolycus*, appeared in 1862; his paper on the early stages of Annelids in 1866; his remarkable memoir on the transformation of *Tornaria* into *Balanoglossus* was published in 1873; and his elaborate embryology of the Ctenophores in 1874. In 1864, Jeffries Wyman, at the time of his death our leading American comparative anatomist and physiologist, published a memoir on the development of the skate. The beautiful memoir of Hyatt on the embryology of Ammonites was a difficult research, while the brilliant papers of Morse on the early stages of the Brachiopod, *Terebratulina*, published in 1869–73, enabled him, by embryological as well as anatomical evidence, to transfer the Brachiopods from the Mollusca to the vicinity of the Annelidan worms. His studies on the carpus and tarsus of embryo birds should also be mentioned. In 1872 Packard published a memoir on the development of Limulus, and pointed out the affinities of its young to certain young Trilobites; and he also published papers on the embryology of the Thysanourous, Neuropterous, Coleopterous, and Hymenopterous insects. S. I. Smith traced the metamorphoses of certain crabs and shrimps. Several entomologists, as Harris, L. Agassiz, Fitch, Riley, Scudder, Packard, LeBaron, Hagen, Cabot, Walsh, Saunders, Edwards, and others, have studied the metamorphoses of insects, while the drawings in illustration of Abbot and Smith's Natural History of the Rarer Insects of Georgia were made by Abbot, who lived several years in Georgia. In 1874 Emerton described the embryology of the spider, *Pholcus*, and during the present year an important memoir by W. K. Brooks on the anomalous mode of development of *Salpa*, a Tunicate, has appeared. We may, then, take an honest pride in the embryological work done by American students; for in this department great activity was shown when scarcely anything was being done in England or France, and the United States have been for twenty-five years past only second in embryological studies to Germany, the mother of developmental zoölogy.

Of anthropological authors, we have room only to speak of Morton, Davis, E. G. Squier, Pickering, L. H. Morgan, Agassiz, Nott and Gliddon, Wyman, J. D. Whitney, Foster, Jones, Abbott, Berendt, Leidy, Baird, Dall, Putnam, C. A. White, Rau, Gillman, Meigs, Jackson, Barber, and a number of men now in the field, chiefly of aboriginal archæology.

The third or evolutional epoch produced an original and distinctively American school of evolutionists. Hyatt's memoir On the Parallelism between the Different Stages of Life in the Individual and those in the Entire Group of the Molluscous Order, Tetrabranchiata, was published in 1867, and several papers extending his views to other groups of Ammonites and Mollusks have appeared since then. Cope's Origin of Genera was published in 1868, and his paper On the Method of Creation of Organic Types, in 1871. Hyatt's views essentially agreed with those published by Cope, but were less general in their application. The theories of both authors are based mainly on the embryological and post-embryonic changes of animals, and on the idea that the different degrees of acceleration and retardation of the growth of the individual are paralleled by those of genera, families, orders, and classes. This hypothesis attempts to account for the origin of the different groups of animals, and, we believe, will lead to a more general and fundamental doctrine than natural selection. As Cope observes, the law of natural selection "has been epitomized by Spencer as the 'survival of the fittest.' This neat expression, no doubt, covers the case; but it leaves the origin of the fittest entirely untouched," and he accordingly seeks for the causes of the origin of the fittest. Here also should be mentioned the writings of Baird, Allen, and Ridgway on the laws of geographical distribution and climatic variation in mammals and birds, which have revolutionized our nomenclature in these classes, and bear directly on the evolution hypothesis. Special attempts to ascertain the probable ancestry of living American mammals have been made by Gill, Cope, and Marsh; of cephalopod mollusks, by Hyatt; of insects, by Packard; and of brachiopod worms, by Morse.

Contributions to the doctrine of natural selection have been made by Dr. W. C. Wells, Rafinesque, Haldeman, Walsh, Riley, Morse, Brooks, and others.

Such has been the progress of zoölogy in the United States within less than a century. Its future progress will in part depend on the attention paid to it by medical students, to whom we may look for treatises on histology and embryology. At present there are no histologists in the United States who have published special monographs. When professorships of zoölogy alone are established in our colleges (at present mineralogy, botany, zoölogy, and geology are often taught by a single person) competent science-teachers will arise for our higher schools, and the science, we may hope, will be cultivated with something of the thoroughness of the German methods. At present we are not so greatly behind France and England as we were twenty years ago. There is, however, danger that Russia will outstrip us, and we are about on a level with the Scandinavians and the Dutch.

With our energy and native ability, and the aid of well-endowed colleges and museums, we may hope hereafter to compete even with Germany. The development of any branch of science is largely dependent on individual students, and every opportunity should be afforded young men of promise of devoting their time to original research. Specialists are sadly wanted in a country like ours, where the tendency is, perhaps, rather to the production of mediocrity than of genius.

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THE MISSING LINK BETWEEN THE VERTEBRATES AND INVERTEBRATES.[1]

THE views which Dr. Dohrn has recently put forth, as to the details of the steps by which the vertebrate stock arose out of an ancestry not very much unlike the existing Annelids, are of such interest that, notwithstanding previous reference to the subject, no apology is needed for presenting the readers of *Nature* with a condensation of the main argument contained in The Origin of Vertebrata.

Dr. Dohrn first draws attention to the correspondences between vertebrate and insect embryos, which have been too little regarded in consequence of our designating the nervous side in the one as dorsal, in the other as ventral. Yet the facts that, in both, the nervous system is developed on the convex side of the embryo and acquires a strong convex flexure anteriorly, and that

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[1] Der Ursprung der Wirbelthiere und das Princip des Functionwechsels: Genealogische Skizzen. Von Anton Dohrn. (Leipzig: Engelmann.)